Specification

Replace Paragraph 9 with the following text:

Fresnel zone plates, or zone plates for short, were invented more than a century ago. As described by most optics textbooks, a zone plate is a transparent plate with a set of concentric zones made opaque to the incident wave. This type of zone plates is sometimes referred to as amplitude zone plates. The outer radius Rn of the nth zone is determined by the following zone plate equation

Replace Paragraph 12 with the following text:

Illustrated in FIG. 2 is a typical transmissive amplitude zone plate 140 under the illumination of an incident wave. The incident wave 142 is diffracted by the clear zones 144 into a series of focal points 146, 147, and 148, with most of the energy being at the first or the primary focal point 148. A corresponding set of virtual focal points, formed on the right-hand side of the zone plate, is not shown here for clarity. Such a zone plate also carries a substantial amount (~25%) of plane wave component in the forward direction. Since half of the incident wave is blocked by the opaque zones 149, this type of zone plates is not very efficient. To overcome the problem of low efficiency, a

phase-reversal zone plate was proposed in 1888 by Lord Rayleigh and demonstrated in 1898 by R. W. Wood, *Philos. Mag.* V45, 51~~(1989)~~ (1898). The basic idea of a phase-reversal zone plate is to convert the opaque zones into transparent zones, and also change the phase of the waves passing through them by 180 degrees. A constructive interference between the diffracted waves coming from the clear zones and those coming from the phase-reversed zones results in a four-fold increase in the intensity of waves at the focal points. Phase-reversal zone plates are often simply referred to as phase zone plates. Phase zone plates have been used frequently in X-ray optics.

Replace Paragraph 50 with the following text:

The present invention provides a diffractive modulator comprising a pair of complementary reflective zone plates. A pair of complementary reflective zone plates 150 is defined according to FIG. 3a. The first reflective zone plate is a zone plate 152 on which the alternate zones 154 (for example, the even zones) are reflective and the remaining zones 156 (for example, the odd zones) are transmissive. Whereas, the opposite zones 159 (for example, the odd zones) on the second reflective zone plate 158 are reflective. The first reflective zone plate 152 is positioned above the second reflective zone plate 158, and is

aligned with the second reflective zone plate so that the centers of both zone plates are on the same axis perpendicular to the zone plates. The radii of the zones on both zone plates are designed with similar parameters so that when the two zone plates are superimposed on top of each other at their centers, they form a complete mirror. When an incident wave impinges upon the pair of complementary reflective zone plates, half of the incident wave is reflected by the first zone plate 152. The other half passes through the first zone plate 152, is reflected by the second zone plate 158, and passes through the first zone plate 152 again. Then the waves reflected from both zone plates combine together. It should be clear to the one skilled in the art that the respective reflective and transmissive zones on a pair of complementary zone plates can be interchanged producing the same wave effect. An improvement to the above complementary reflective zone plates is shown in FIG. 3b. A mirror 160 is used to substitute the second reflective zone plate. Since the transparent zones 156 of the first reflective zone plate 152 determine the active regions on the mirror, it automatically creates a self-aligned zone plate <u>on the mirror 160</u> that is complementary to the first zone plate 152. The improvement greatly simplifies the construction of the zone plates and also eliminates the need of alignment between the zone plates.

Replace Paragraph 93 with the following text:

The optical properties of the zone plate modulators described so far depend on the wavelength of the incident wave. For a zone plate modulator designed for C-band (λ = 1525nm ~ 1562nm) applications, the output intensity varies by as much as 3 dB across the band at an attenuation of - 40 dB. For certain applications such as variable optical attenuators (VOA), it is highly desirable to have a wavelength independent modulation/attenuation. Godil et al. (~~*Achomatic*~~ *Achromatic optical modulator*, U.S. pat. No. 6,169,624, issued on January 2, 2001) described a method of compensating the wavelength dependence for optical attenuators that operate based on the principle of light beam interference.

Replace Paragraph 94 with the following text:

According to prior art, a typical modulator as illustrated in FIG. 17a consists of a first reflective surface 400 and a second reflective surface 402 having equal amplitude $E1 = E2 = E0$. The two surfaces are suspended above a substrate 404. The idea of compensating the wavelength dependence described by Godil et al. (~~*Achomatic*~~ *Achromatic optical modulator*, U.S. pat.

No. 6,169,624, issued on January 2, 2001) is to split one of the two surfaces, say the second reflective surface 402 as shown in FIG. 17a, into a reference surface 402r and a compensating surface 402c having an amplitude *E2r* and *E2c* respectively as shown in FIG. 17b. In the un-deflected configuration, surfaces 400 and 402r are co-planar, and are suspended above the compensating surface 402c by a distance $Da = (N \lambda)/2$, where N is an integer and λ is the center wavelength of the incident wave. To achieve an achromatic or wavelength independent attenuation, the amplitude of *E2c* is set to equal to $E2c = E1 / (2N)$. Therefore, the achromatic performance of the attenuator is determined by a single parameter *Da*.